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As an instance typical of that unevenness of treatment previously mentioned the genus *Samaropsis* may be examined with some slight detail. In Fig. 502 A on page 350 are shown three figures copied from Dawson of *Samaropsis fluitans*. This species is apparently selected for discussion and illustration since this name appears in many lists of Carboniferous fossils from various localities. Dawson's figures are notoriously unreliable, as is very well known on this side of the Atlantic, and his types of *Samaropsis fluitans* scarcely deserve to be taken up as the types of anything. Now if we turn to *Samaropsis fluitans* as identified by Weiss we find that it represents an altogether different object. Similarly Kidston's and Zeiller's *Samaropsis fluitans*, while they are identical with one another, can hardly be considered as identical with either Dawson's or Weiss's objects so named and Grand'Eury's *Samaropsis fluitans* is a still different object. Turning to the second species shown in this figure, namely *Samaropsis emarginatum* of Goeppert & Berger, we find that the type figures are absolutely unrecognizable. We find that Geinitz referred two totally different forms to this species, Hoffman & Ryba's determination of it is questionable, Feistmantel's forms of this name are still different, and Kidston's figures of 1902, 1908 and the present work can scarcely be regarded in any single instance as representing any of the previous determinations. If we turn now to C and D of this same figure, supposed to represent *Cordaicarpus Cordai* of Geinitz we find that Geinitz figured a variety of things under this name, but he expressly states in his text that these seeds are 2 cm. in diameter and sometimes twice that size and tumid. When we turn to Zeiller's, Kidston's or Vernon's figures called by this name we find a tiny, often flat, form, totally unlike anything that Geinitz figured. It may also be suggested that E of this figure is upside down and that instead of having a *Samaropsis bicaudata* we have a *Samaropsis bicornuta*, for which there are analogies in other species of *Samaropsis*.

These instances may be taken to illustrate my criticism that unsatisfactory forms were

selected for figuring in the present work without any digestion of the subject simply because the names occur frequently in the literature, a method of procedure which not only entirely obscures any chronologic value that these objects might have, but crowds out figures or discussion of really good material. The case may be stated something as follows: The poorer the type material of a species the more readily will other things be confused with it and so in the course of time it is always the least recognizable and the poorest types that become credited with the greatest range, both geological and geographical.

This sort of criticism might be legitimately applied to many other items in the present volume. These are almost always subjects outside of Professor Seward's own specialty, and subjects in which I fancy he is not greatly interested, and while they do not detract from the value or accuracy of that part of the work where the author is on familiar ground, an author should not pose as an authority on phases of work in which he shows no apparent interest or willingness to give the labor necessary to the mastery of the literature, so much of which it is admitted is of minor value.

For this very reason and the further reason previously mentioned of Seward's attitude regarding what constitutes a fossil species, it may be considered very fortunate that the author has been unable as yet to carry out his intention of discussing the geographical and geological distribution of fossil plants.

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SPECIAL ARTICLES

THE GLASS SANDS OF PENNSYLVANIA

AT present in the manufacture of glass, nearly pure quartz sands are used almost exclusively as the source of the silica which is the major constituent of all the common varieties of this useful substance. An ideal glass sand would be one made up entirely of grains of the mineral quartz. Sands containing 100 per cent. silica, however, are not found in nature, although some very nearly approach

this composition. When a complete chemical analysis of a glass sand is made, minute amounts of alumina, ferric and ferrous oxides, magnesia, lime, titanium oxide, traces of the alkalies, and varying amounts of water are usually found to be present. Some of these constituents are harmless, while others have a very deleterious effect upon the glass.

Alumina imparts both desirable and undesirable properties to the resulting glass. It reduces the tendency of the glass to devitrify or crystallize. It decreases the solubility of the glass in water, weak acids, and other reagents, which is very desirable in the case of bottles and chemical glassware. It increases the surface tension of the glass when chilled rapidly, which is beneficial in molding, as the glass will not take on the minor imperfections of the mold, while, on the other hand, it will still be sufficiently viscous to assume the general shape of the mold. It reduces the coefficient of expansion of the glass and increases its tenacity, a feature also desirable in the case of bottles and chemical glassware. Alumina in glass facilitates annealing. It also makes the glass somewhat harder and a little more brilliant. An undesirable feature is that alumina tends to decrease the fusibility of the glass and increases its viscosity. It should, therefore, not be present in amounts exceeding 3 per cent. Also glass cullet containing alumina does not mix well with other glass and, therefore, tends to produce cords or striæ when used. The light blue tint noticeable in certain glasses made from salt cake is thought by some observers to be due to alumina in the form of a compound analogous to ultramarine blue. Alumina may occur in glass sands in the form of kaolinite, mica, feldspar, or hornblende. If it is present as kaolinite or mica it may be largely removed by washing.

Iron in the form of either ferric or ferrous oxides is the most detrimental impurity found in glass sands on account of its coloring effect upon the glass. Ferrous iron imparts a bluish green tint upon glass, while ferric iron produces a yellow tint, which is not nearly so noticeable. Since most glass is made under reducing conditions, the green color is the

one usually developed. Where the amount of iron present is small, this coloring effect can be in part overcome by the use of manganese dioxide, nickel oxide or selenium. For the best grades of optical glass the percentage of ferric oxide present in the sand should not exceed .002 per cent. For the better grades of lead flint used in the manufacture of cut glassware it should not exceed .02 per cent. In the case of plate glass to be used for mirrors the ferric oxide should not be over .1 per cent., while in the case of plate glass to be used by transmitted light it may run up to .2 per cent. For window glass the amount may be as high as .5 per cent., while in the case of ordinary green and brown bottles sands containing from .5 to as high as 7.0 per cent. ferric oxide is used. Iron may be present in the sand in the form of limonite, hematite, magnetite, ilmenite, biotite, hornblende, or chlorite. A little may also be introduced as metallic iron from the machinery used in crushing the sandstone to sand. If it is present as limonite or hematite closely associated with the kaolinite or clay, it may be in large part removed by washing. If, on the other hand, the limonite or hematite adheres closely to the quartz grains washing will be of no avail. The other minerals mentioned can not be readily removed by washing.

The small amounts of magnesia and lime occasionally present in glass sands have no detrimental effect upon the glass. All the common varieties such as plate, window, and bottle glass contain lime as an essential constituent. Magnesia is much more apt to be introduced into the glass batch through the limestone used than through the sand. The composition of this material, therefore, must be watched with respect to this constituent. Alkalies, likewise, enter into the composition of glass and the minute traces occasionally present in the sand, therefore, are not harmful. Titanium oxide never occurs in sufficient amounts to have any detrimental effects upon the glass. It usually occurs in the sand as minute hairlike inclusions of rutile in the quartz grains, themselves. In the case of the better grades of glass such as optical, lead

flint, and plate, the sand is always carefully dried before being used.

In size for ordinary purposes of glass manufacture practically all of the sand grains should pass through a 30-mesh sieve, or in other words have a diameter less than .64 millimeters. The majority of the grains should be retained on a 120-mesh screen, or be over .136 millimeters in diameter. For optical glass, all of the sand should pass through a 48-mesh sieve. The shape of the grains has little to do with the relative values of the sand, although perhaps an angular sand is a little more desirable than one in which all of the grains are well rounded, other factors being equal.

In 1915, Pennsylvania produced 455,112 tons of glass sand. This represents about one fourth of the total production of glass sand in the United States. Pennsylvania holds this important rank as a producer of glass sand for two reasons: first there are found within her borders an abundant supply of nearly pure quartz sandstones that yield when crushed an excellent grade of sand, and secondly the center of the glass industry of the United States is located in western Pennsylvania so that there is a great demand for such sand. Nearly all of the glass sand at present produced in Pennsylvania comes from two formations, the Oriskany of the Devonian and the Pottsville of the lower Pennsylvanian. Of these the Oriskany is by far the more important.

The Oriskany formation occupies the belt of Appalachian folding which crosses Central Pennsylvania and which reaches a maximum width of nearly 56 miles. It varies greatly in this area both in thickness and in character. In Huntingdon and Mifflin counties a pure quartz sandstone phase, which has a thickness of from 60 to 200 feet, is particularly well developed. In its unaltered state it is a hard bluish-gray quartzite made up of interlocking grains of quartz in which silica in parallel orientation with the original grains is the bond. Under favorable conditions of weathering this has become disintegrated to a friable sandstone, or in some places even to a loose sand. These are the portions that are used for

glass sand. For this purpose the sandstone must be sufficiently friable so that small pieces may be broken up between the fingers into loose sand. In preparing it for the market the rock is passed through a jaw crusher and chaser mill or wet grinding pan to disintegrate it into loose sand. It is then screened, passed through a screw conveyor type of washer, and the excess water is allowed to drain off, and the sand is dried in a steam or direct heat dryer. After a final screening it is ready for the market. Much of the best grade of glass sand produced in the United States comes from this district.

The Pottsville formation of western Pennsylvania is divided into five members as follows, commencing at the top: the Homewood sandstone, the Mercer shale, the Connoquenessing sandstone, the Sharon shale, and the Sharon or Olean conglomerate. Of these portions of the Homewood and the Connoquenessing sandstones are at times sufficiently pure quartz sandstones to be available for glass sand. The sand derived from them, however, is never as pure as that from the Oriskany of central Pennsylvania and is, therefore, used only in the manufacture of the cheaper grades of glass such as bottle and window glass. A little is also used in the plate-glass industry. The method of treatment is usually the same as that used on the Oriskany sandstone in central Pennsylvania, except that drying is usually dispensed with. Sometimes, however, the rock is simply crushed dry and screened, washing not being resorted to.

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